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National Aeronautics and Space Administration
1520 H Street N. W.
Washington 25, D. C.

Attention: Office of Grants and Research Contracts, Code SC

Gentlemen:

This letter is a report of progress on Research Grant NsG-365, entitled "Theoretical Studies on the Relationships Between the Thermionic Work Function of Refractory Intermetallic Compounds and Their Electronic and Crystal Structures," for the period 1 January 1964 to 31 June 1964.

1.0 Introduction

All of the group VI-A metals form intermetallic compounds with rhenium. In the chromium-rhenium system, a single σ-compound is observed. The molybdenum-rhenium and tungsten-rhenium systems also form the σ-compounds as well as another intermediate phase having the α-Mn structure. The objective of the present study is to measure the thermionic work functions of the five compounds and determine how they are related to the electronic and crystal structures.

Considerable attention was given to the fabrication of specimens during the report period just past, although the major effort was expended in design and construction of equipment as described in the following two sections of the report.

2.0 Fabrication of Specimens

The specimens required for accurate determination of the work function are of two types. The cathode of the thermionic diode is a wire-like specimen, 10 mils in diameter. The emissivity specimens are of 1/4-in. diameter tubing 7 in. long, having a 1/8-in. diameter hole drilled radially at the midpoint.

At the time of the last progress report, electrophoretic deposition of the finely ground materials on a refractory-metal substrate was being considered as a possible method for specimen fabrication. Although the process

is itself not difficult, contamination of the finely ground particles by iron during grinding presents a serious problem. For this reason, another method involving reduction of gaseous hexafluorides or carbonyls on the refractory-metal substrate was extensively surveyed. Leitten[1] and Holzl[2] have been active in development of the process but as yet have not done sufficient work with the binary systems of the present investigation. Holzl was contacted as a possible subcontractor; although his firm was willing to accept the work on a best-effort basis, the time and costs were prohibitive for the present study, and a return to the electrophoretic deposition technique seemed judicious. Magnetic separation, followed by an acid leach are presently being used in an attempt to eliminate the iron contamination, and analyses for iron will be available during the next report period.

3.0 New Equipment

During the past report period, a major effort was expended in the design and construction of a high-voltage pulse generator and a high temperature vacuum furnace.

The pulse generator, patterned after a design by Haas, is capable of producing pulses of up to 15KV over a wide range of pulse widths and repetition rates. For the diodes used in the present investigation, which have a 10-mil diameter emitter surrounded by a 7/8-in. diameter collector, the 15KV potential is equivalent to an electric field intensity of about 260,000 v/cm. While some low-field determinations of work function have been made by the method described by Hensley[3], the much higher fields are necessary to obtain the Schottky plot, from which the zero-field emission is obtained by extrapolation.

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[1] Leitten, C. F., Private Communication, Metals & Ceramics Div., Oak Ridge National Laboratory, Oak Ridge, Tenn., (May 1964).

[2] Holzl, Robert A., Private Communication, San Fernando Laboratories, P. O. Box 727, Pacoima, Calif., (May 1964).

[3] Hensley, E. B., "Thermionic Emission Constants and Their Interpretation," J. Appl. Phys., 32, 301-308, (1961).

The high temperature vacuum furnace, now about 90 percent complete, was constructed in order to obtain an accurate temperature correction, since the emitter temperatures in the diode are measured with an optical pyrometer. The tube specimen described in the previous section is held between 2 water-cooled copper electrodes, thus forming a resistance element. The inside of the tube-specimen closely approximates the ideal blackbody condition, and is viewed through the 1/8-in. hole at the center of the tube. The optical pyrometer reading inside the tube is compared with a reading taken on the tube surface, and the correction is then applied to temperature measurements taken on the diode emitter.

4.0 Discussion of Future Work

Actual diode fabrication will commence by August 15 and will be completed by September 15. Measurements can be made by the end of September. It is anticipated that the proposed research will be completed by November 30, 1964.

Respectfully submitted,

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